Closure Strategy for a Waste Disposal Facility with Multiple Waste Types and Regulatory Drivers at the Nevada Test Site - 8422

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ABSTRACT

The U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) plans to close the waste and classified material storage cells in the southeast quadrant of the Area 5 Radioactive Waste Management Site (RWMS), informally known as the "92-Acre Area," by 2011. The 25 shallow trenches and pits and the 13 Greater Confinement Disposal (GCD) borings contain various waste streams including low-level waste (LLW), low-level mixed waste (LLMW), transuranic (TRU), mixed transuranic (MTRU), and high specific activity LLW. The cells are managed under several regulatory and permit programs by the U.S. Department of Energy (DOE) and the Nevada Division of Environmental Protection (NDEP). Although the specific closure requirements for each cell vary, 37 closely spaced cells will be closed under a single integrated monolayer evapotranspirative (ET) final cover. One cell will be closed under a separate cover concurrently. The site setting and climate constrain transport pathways and are factors in the technical approach to closure and performance assessment.

Successful implementation of the integrated closure plan requires excellent communication and coordination between NNSA/NSO and the regulators.

INTRODUCTION

The Area 5 RWMS at the Nevada Test Site (NTS), about 105 kilometers (65 miles[mi]) northwest of Las Vegas, Nevada, consists of closely spaced shallow and intermediate depth cells used to store classified materials and to dispose of waste. NNSA/NSO is planning to close the 38 oldest cells located in the southeast quadrant of the facility by 2011. The area to be closed is informally known as the 92-Acre Area. Burial operations began in January 1961, and most of the cells are full and already operationally closed. The regulatory agencies involved and the specific closure requirements for each cell depend on the waste type, disposal dates, and applicable permit conditions. Integrated closure planning and the final closure cover design must take into account the site conditions and regulatory requirements. This paper provides a brief overview of the Area 5 RWMS site characteristics and disposal history pertinent to the closure strategy, identifies key issues, and presents the closure strategy. The integrated closure strategy requires a few negotiated adaptations and compromises as well as excellent communications between agencies for successful implementation.

SETTING

The site setting and climate constrain transport pathways and are key factors in the technical approach to closure and performance assessment. The Area 5 RWMS is located within the NTS, an access-controlled 3,561 square kilometer proving ground and training facility managed by the DOE. The Area 5 RWMS is not readily accessible by the public and is located far from existing residential communities; land use in the region is constrained by federal land ownership and management policies. The Area 5 RWMS is in Frenchman Flat, a remote, arid basin that has been used for decades for research and testing, including underground and atmospheric nuclear testing.

The NTS has a climate characterized by low precipitation, a large diurnal temperature range, a large evaporation rate, and moderate to strong winds. Annual potential evapotranspiration (PET) far exceeds annual precipitation even in relatively wet years. The alluvium below the Area 5 RWMS is approximately 914 meters (m) (3,000 feet [ft]) thick, and depth to groundwater in the uppermost aquifer from ground surface is about 235 m (772 ft) at adjacent monitoring well UE5PW-1. The nearest spring is Cane Spring, about 14.4 km (9 mi) southwest of the Area 5 RWMS. The spring's source is mountain-front recharge through fractures. There is a playa several miles downgradient of the Area 5 RWMS that periodically retains stormwater [1].

National Security Technologies, LLC (NSTec) [2] identified few natural resources that would potentially influence waste-disturbing human intrusion in the Area 5 RWMS. There are mineral districts on the NTS, but none are near the Area 5 RWMS, and there are no reports of economic mineral deposits in the unconsolidated alluvium. There are no significant oil or gas resources in Southern Nye County, which includes the NTS. The Area 5 RWMS is unlikely to be excavated for sand and gravel because sand and gravel are abundant in the region, and there are better quality sources of sand and gravel for construction in the area than at the Area 5 RWMS.

Irrigated agriculture potential is constrained by low productivity of the soils, water supply regulations, and the cost of developing water supplies. Vegetation characteristics suggest it would be poor rangeland for grazing. Water demands for human consumption may create future economic demand for development of the deep carbonate aquifers of the region; however, the Area 5 RWMS is not an optimal location for tapping this aquifer.

The facility location and setting are well-suited for shallow and intermediate depth burial of waste. The climate and hydrogeologic setting are key factors in performance of the waste containment in shallow landfill cells. The arid climate, dry alluvial fill, lack of shallow groundwater, and shallow-rooted plants, which are adapted to be very efficient at capturing and utilizing infiltrating water, reduce the risk of water moving through the waste cell and leaching contaminants.

The lack of economically developable resources in the immediate site vicinity reduces risk of inadvertent intrusions in the far future after institutional controls end. Potential for downward migration of fluid and contaminants is small. The focus of long-term containment system performance evaluations is on the upward migration pathways through the cover.

DISPOSAL HISTORY

Burial of LLMW and classified materials in shallow pits and trenches began at the Sugar Bunker Dump in 1961, prior to the formal establishment of the NTS Waste Management Program, the adoption of strict waste acceptance criteria, the establishment of the Area 5 RWMS, and the adoption of the Resource Conservation and Recovery Act (RCRA). Early waste disposal inventory records are less detailed and complete than modern records, but indicate through descriptions that some hazardous constituents may be present. Based on the unclassified waste disposal inventory records, the early cells may have received some LLMW, and at least two cells received biological waste from an NTS research farm. Ten of these early pits and trenches have been identified as Corrective Action Unit (CAU) 111 under the *Federal Facility Agreement and Consent Order* (FFACO). CAU 111 is also identified in the NTS RCRA permit (NEV HW0021) as a historic site that must be closed in accordance with RCRA Title 40 Code of Federal Regulations (CFR) Part 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," requirements. Administratively, RCRA compliance for CAU 111 is handled through FFACO. Figure 1 shows the layout of the landfill cells.

Initially much of the LLW buried in Area 5 was from remediation and demolition of nuclear test sites and facilities at the NTS. In 1978, the DOE formally established the Area 5 RWMS and began promoting it as a disposal site to other DOE complex facilities. The number of generators and diversity of the waste streams increased. Waste tracking systems and profiling significantly improved.

In the early 1980s, the Greater Confinement Disposal Test (GCDT) demonstrated the feasibility and safety of intermediate burial of waste at the Area 5 RWMS. By 1989, a total of 13 boreholes, 36.6 m (120 ft) deep, were drilled, and 9 were used for disposal of classified material and waste. The GCD deposits include high specific activity LLW, transuranic (TRU), and small volumes of mixed TRU.

In 1986, approximately 1.2 kilograms (2.6 pounds) of TRU were buried accidentally in shallow trench T04C. The TRU is distributed within a large number of containers of classified LLW. The approximate location of the TRU has been inferred from historic photos and disposal dates, but the precise location and configuration within the trench is unknown. Special assessment simulations of containment performance indicate the shallow containment configuration is adequate to meet DOE assurance requirements and performance requirements. Although a retrieval plan has been maintained, the current strategy is to close the shallow TRU in place.

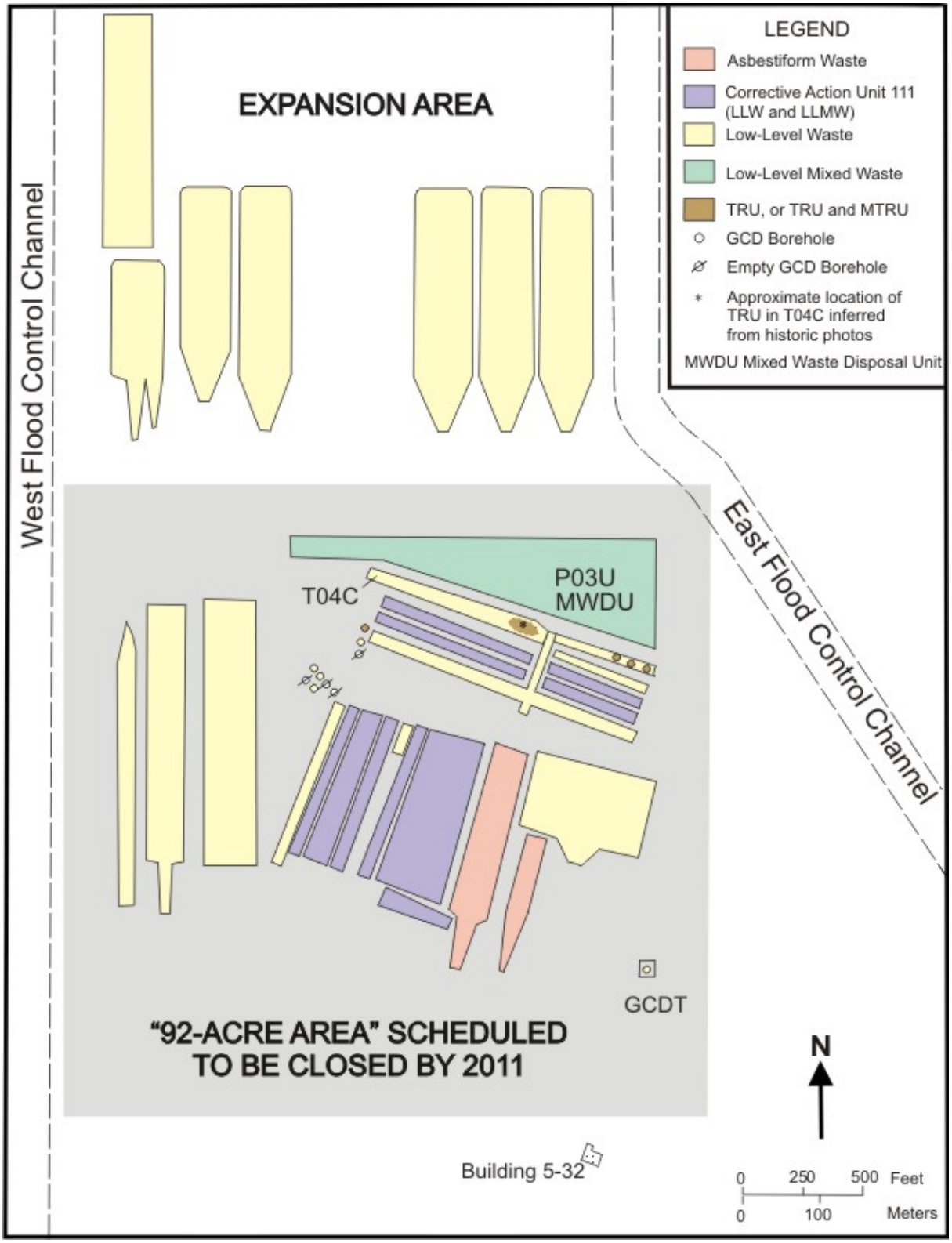

Fig. 1. Landfill Cell Map

Two pits are permitted by the state of Nevada as a Class III solid waste disposal site for the disposal of asbestiform LLW. These primarily receive demolition debris from NTS sites. One of these pits was deepened for the disposal of thorium waste. Transport modeling indicates the final closure cover over this waste is adequate to mitigate radon migration from the waste packages, but radon flux through the landfill covers is being monitored routinely.

The Pit 3 mixed waste disposal unit (MWDU) is operated under RCRA Interim Status under permit NEV HW0021. Waste operations are scheduled to end by December 2010. U.S. Environmental Protection Agency (EPA) regulatory closure timelines for Pit 3 drive the closure schedule for the 92-Acre Area.

CLOSURE STRATEGY

Integrated closure of the 38 units in the 92-Acre Area requires compliance with overlapping requirements administered by multiple agencies. The types of units are physically intermingled; however, for the purpose of closure planning and compliance, the units can be grouped in six closure units by closure requirements and approval path to closure. Table I summarizes the principal closure regulations and approval authorities involved in closure of each of the six closure units.

To address conflicts and redundancies in the specific design guidelines, closure plan requirements, timeframes, and prescriptive controls across the site, the integrated closure approach involves the following:

- Adoption of the most restrictive timeframes and standards
- Development of program-specific closure plans and closure reports as necessary to cover disparate content requirements
- Approval of an alternative cover design that meets the performance criteria of multiple programs
- Negotiation where the prescriptive details of overlapping program requirements are excessive, but the intent can be met with an efficient compromise (e.g., signs and monuments)

The integrated approach also leverages the protection and hazard communication benefits of use restriction programs applicable to portions of the Area 5 RWMS site and nearby sites.

Table I. Area 5 RWMS 92-Acre Area Closure Units

Closure Unit	Waste Units	Status of Operations (November 2007)	Waste Type/ Material	Principal Closure Regulations	Path to Closure	Approval Authority
LLW Unit	Ten trenches and pits, five LLW GCD boreholes, and four empty GCD boreholes	Twelve are operationally closed. Pit P09U is active. There are four open empty boreholes and two waste boreholes ready to be backfilled.	LLW	DOE O 435.1	Approved PA/ICMP; DOE Closure Plan; Closure Report; Recommend NNSA/NSO approval authority	NNSA/NSO
TRU GCD Borehole Unit	Four GCD boreholes and one LLW trench overlying three of the boreholes.	Operationally Closed	Boreholes: TRU, and other types varying by unit (MTRU, Suspected MTRU, LLW, LLMW) Trench: LLW	DOE O 435.1 Title 40 CFR 191 TFRG Criteria	PA conditions met. Addendum to PA for TFRG Approval; DOE Closure Plan; Closure Report	NNSA/NSO TFRG
TRU Trench Unit	Trench T04C	Operationally Closed	LLW, TRU (1.2 kilograms TRU inadvertently disposed of in 1986)	DOE O 435.1 Title 40 CFR 191 TFRG Criteria	DOE Closure Plan; Closure Report	NNSA/NSO TFRG
Asbestiform Unit	Two pits	P06U is active. P07U is operationally closed.	Asbestiform LLW	Nevada Solid Waste Disposal Site Permit #SW 1300001 DOE O 435.1	As per the permit; Closure Plan; Closure Report	NNSA/NSO NDEP (BOFF)
CAU 111 Unit	Ten trenches and pits	Operationally Closed	LLW/ suspected LLMW	FFACO, RCRA Part B Permit # NEV HW0021, Title 40 CFR 265 DOE O 435.1	CAU 111-specific Characterization Report, Closure Plan, and Closure Report	NNSA/NSO NDEP (BOFF)
Pit 3 MWDU	Pit P03U	Active	LLMW	RCRA Part B Permit # NEV HW0021 DOE O 435.1	As per the RCRA permit; Closure Plan; Closure Report	NNSA/NSO NDEP (BOWM)

BOFF Bureau of Federal Facilities
BOWM Bureau of Waste Management
CFR Code of Federal Regulations
DOE U.S. Department of Energy
FFACO *Federal Facility Agreement and Consent Order*
GCD Greater Confinement Disposal
HQ Headquarters
ICMP Integrated Closure and Monitoring Plan
LLW Low-Level Waste
LLMW Low-Level Mixed Waste
MTRU Mixed Transuranic
MWDU Mixed Waste Disposal Unit
NDEP Nevada Division of Environmental Protection
NNSA/NSO U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
PA Performance Assessment
RCRA Resource Conservation and Recovery Act
TFRG TRU Federal Review Group
TRU Transuranic

Pre-Closure

In fiscal years 2008 and 2009, prior to implementation of final closure, three remaining active cells will be operationally closed, and four empty GCD boreholes will be backfilled with native soil.

The operational closure covers of 37 closely spaced cells will be integrated into a contiguous operational cover through emplacement of fill between covers concurrently with drainage improvements to ensure stormwater continues to drain away from the cells.

Closure plan formats differ significantly between DOE guidance, FFACO guidance, and RCRA guidance. To meet agency-specific guidance and facilitate review, four closure plans are being prepared or updated for the 92-Acre Area. The core plan will be a Closure Plan prepared for review by DOE headquarters, the Low-Level Waste Disposal Federal Review Group (LFRG), and the Transuranic Federal Review Group (TFRG). The plan will focus on the LLW cells, the GCD TRU cells, and trench T04C.

NDEP has direct authority for administering closure of the asbestiform LLW units under the solid waste permit, has authority for implementing RCRA from EPA, and must approve the closure of corrective action units under FFACO. Because the details of closure plan requirements vary, DOE is preparing separate plans for closure of the asbestos solid waste landfill units, the Pit 3 (P03U) MWDU, and CAU 111.

After the plans are approved as appropriate by NDEP and DOE headquarters, NDEP will be notified at least 60 days prior to commencement of final closure construction activities.

Greater Confinement Disposal Test

Of the 38 cells in the 92-Acre Area of the Area 5 RWMS, 37 will be closed under a single integrated cover. The GCDT facility is located far enough from the other units to be closed independently. The waste packages in the borehole are covered by 21.3 m (70 ft) of native alluvium. The GCDT was operationally closed after seven years of testing. The monitoring boreholes surrounding the waste borehole were plugged, and a concrete slab and thin soil cover constructed over the test site. For final closure, the boundary fencing and warning signage will be improved. The existing cover may be vegetated to improve evapotranspiration above and around the edges of the concrete slab.

Cover Design and Construction

A monolayer ET closure cover design was selected because it is well-suited to the climate and site characteristics; provides stability, maintenance, and cost advantages; is equivalent to a standard RCRA design; and DOE has had success with this design at other sites, including closure of U-3ax/bl, a LLMW cell in the Area 3 RWMS, located 24 km (15 mi) north of the Area 5 RWMS. The cover is designed to meet DOE, EPA, and Nevada closure requirements for the varied waste inventory. The final cover will have a footprint of approximately 29 hectares (72 acres). The final earthen cover will be constructed in accordance with the approved design and

Construction Quality Assurance Plan. The surface will be vegetated with native species of plants. The boundary will be fenced and posted.

Reporting and Documentation

Implementation will be documented through field operations paperwork, engineering inspection reports, and progress reporting activities. A closure report or reports will be prepared for the LLMW units in accordance with FFACO and RCRA requirements and submitted to NDEP. The closure report includes a certification statement that the construction was completed in accordance with the closure plans. A final survey and site plan will be developed. The survey plat will be placed in public records. Use restriction records will also be public records.

Closure certification will also be provided to NDEP within 60 days of completion of the post-closure care period for the RCRA-regulated closure units in accordance with 40 CFR 265.120.

Classified Material

The final cover for the RCRA-regulated units including the Pit 3 MWDU and CAU 111 is meant to be a permanent final cover, not to be disturbed. However, there is classified material within some of the 92-Acre Area cells. Under current DOE orders and policies, buried classified material is not waste and is considered in storage and retrievable. Current sanitation standards for declassifying the material are cost prohibitive. DOE is exploring pathways and evaluating the risks to have the classified material at the Area 5 RWMS deemed disposed waste.

TRU in Trench T04C

DOE contractors performed a special assessment to determine if the current disposal configuration meets performance objectives of DOE M 435.1-1, “Radioactive Waste Management Manual.” The small volume of TRU poses no containment issues. NNSA/NSO has maintained a plan for retrieval in accordance with Title 40 CFR Part 191.14, “Assurance Requirements,” but currently plans to close the waste in situ.

GCD Borings with TRU and MTRU

Four of the nine utilized GCD boreholes contain TRU. Two of these contain at least one package of material that may now be deemed MTRU based on waste characteristics, and two are suspected to contain MTRU, but there is insufficient unclassified profiling information to confirm. Chu and Bernard [3] summarized available unclassified information on the GCD borehole inventory.

A separate performance assessment was prepared for the GCD borings [4]. NSTec has a paper in review presenting the detailed strategy for compliance with 40 CFR 191.14. The NNSA/NSO maintains a retrieval plan but currently plans to close the waste in situ.

Modeling indicates no additional engineered barrier is necessary beyond the planned monolayer ET closure cover.

Initial evaluations suggest the cost to implement an additional barrier such as a boulder mound, boulder wall, or concrete slab offers very marginal benefits. The thick earthen landfill cover alone appears to meet DOE's as low as reasonably achievable requirement. Further details will be published in documents, currently in review, prepared by NSTec for NNSA/NSO.

Asbestiform LLW

An alternative cover design that provides similar or better protection has been proposed in lieu of the construction specifications in Nevada Administrative Code (NAC) for closure of a solid waste landfill (NAC 444.6891, "Requirements for design and construction of system for final cover"). It is expected that after review of the final grading and drainage plans, the NDEP will provide an exception from the minimum 3 percent cover slope requirements under NAC 444.6891. The monolayer ET cover grading plan mitigates potential ponding and provides drainage while maintaining erosion protection and slope stability.

CAU 111

The closure plan for CAU 111 will fulfill the needs of both a FFACO Corrective Action Plan as well as the information requirements for a RCRA landfill closure plan. The waste will be closed in place with a use restriction. The FFACO use restriction will include information on the entire 92-Acre Area, not just the CAU 111 cells. The location and dimensions of the CAU 111 cells will be mapped, along with the boundary of the entire final capped area. FFACO use restriction postings will be incorporated with other required warnings on the fencing around the final cover. Monuments will define the boundary of the integrated final cover. Permanent survey monuments will be maintained to enable future location of any cell within the 92-Acre Area. The proposed monolayer ET cover design is RCRA-equivalent and has been implemented successfully at other DOE sites.

POST-CLOSURE CARE STRATEGY

Active Care Period

RCRA requires 30 years of active post-closure care for the cells containing regulated mixed waste. The performance assessment assumption for the Area 5 RWMS is that DOE (or the following federal landlord) will have active institutional control of the site for at least 100 years. Inspections, maintenance, and monitoring will continue through the active care period unless conditions indicate these activities are no longer required and the regulators approve changes to the closure plans.

DOE requires evaluation of the containment systems likelihood to meet specific quantitative performance objectives over a 1,000-year time period. The performance assessment and composite analysis maintenance plan [5] provide a routine to ensure that post-closure monitoring, inspections, and maintenance are modified as needed to respond to changing conditions while there is active institutional control of the site. Passive institutional controls will continue to provide some protection into the future.

Environmental Monitoring Plan

An integrated monitoring plan will be developed for the Area 5 RWMS to meet both ongoing operational needs and post-closure care requirements for the closed portions of the facility. Consideration of NTS-wide surveillance program needs will also be considered. This monitoring plan will be reviewed periodically and updated as needed to respond to data trends and changing conditions through the Performance Assessment and Composite Analysis Maintenance process required by DOE.

Post-Closure Monitoring is anticipated to initially include the following:

- Vadose zone moisture monitoring
- Radon flux
- Air for radionuclides
- Soil gas for tritium
- Meteorological parameters
- Subsidence observations
- Biotic monitoring for radionuclide uptake
- Groundwater

It is assumed the RCRA groundwater monitoring for the Pit 3 MWDU will also serve the monitoring needs for CAU 111. Site characterization studies and transport modeling suggest there is no significant movement of water and contaminants downward below the landfill. Estimated time for radioactive contaminants to reach the groundwater table is over 10,000 years [6]. The risk of a well being drilled through the landfill in the future is deemed to be small. Because there is underground contamination from a historic nuclear test less than 3 km (2 mi) from the Area 5 RWMS, the primary value of groundwater monitoring at the Area 5 RWMS may be to support the Underground Test Area (UGTA) program. The data may indicate whether contaminants from the UGTA Frenchman Flat CAU are migrating into groundwater below the Area 5 RWMS.

Inspections and Maintenance

During the active institutional control period, the inspection and maintenance program ensures fencing, signs, and markers are maintained; helps document cover conditions and processes over time; and ensures the cover system is maintained.

Site Security

NTS year-round all-hours site security and Area 5 RWMS security programs limit access to the site and reduce risk of intrusions into the waste.

Postings and Monuments

All the regulatory programs have the same basic intent: to mitigate release of contaminants and to protect the public and environment from potential harm. To resolve overlapping and sometimes detailed program-specific prescriptive requirements for passive institutional controls

such as signage and monuments, a unified compromise approach will be proposed that fulfills hazard communication needs without excessive redundancy. Legible warning signs summarizing the buried hazards and points of contact for further information will be posted around the perimeter fence at a practical interval that will ensure that a person driving or walking near the enclosure will see a posting. Relatively durable monuments will define the edges of the final cover. No monuments or signs are expected to remain intact and legible for the DOE's 1,000-year performance compliance period.

No postings or monuments will be placed to define individual cells within the closed area to minimize penetrations of the cover and facilitate maintenance.

Survey benchmarks will be maintained. Individual cells will be locatable after final closure through land surveys from these points.

Use Restrictions

The FFACO UGTA Frenchman Flat CAU consists of ten sites with deep underground contamination. Investigations are not complete, but it is anticipated that the initial corrective action will be to define a contaminant containment boundary and establish a 1,000-year use restriction for the groundwater. The Area 5 RWMS is expected to fall near the edge of the defined area. DOE Environmental Management staff has made an administrative decision to include the Area 5 RWMS within the groundwater use restriction boundary, whether or not the final modeling supports its inclusion.

Inclusion of the Area 5 RWMS in the Frenchman Flat groundwater use restriction area provides a powerful administrative control on water well drilling for up to 1,000 years after closure. This groundwater use restriction also affects the choice of scenarios for performance and composite assessment evaluations, as the inadvertent drilling of a groundwater well within the Area 5 RWMS is far less likely.

The FFACO use restriction for CAU 111 will include information on the buried waste hazards for the entire 92-Acre Area. The use restriction will be recorded in the DOE Facility Information Management System and the Central Data Repository.

Public Records

Public records provide a means of notifying future landowners of the location and nature of buried waste. Information regarding the location and nature of the site hazards will be preserved in the survey plat, closure reports, and use restriction databases maintained by public agencies.

CONCLUSIONS

Integrated closure of the 92-Acre Area requires compliance with overlapping requirements administered by multiple agencies. Although the overall intent of the programs are the same (to protect human health and the environment), the specific closure plan requirements, timeframes, and details of passive and active institutional control strategies conflict in some areas. To

successfully integrate closure activities at the Area 5 RWMS, the most protective timeframes and monitoring requirements are adopted. Multiple closure plans are being prepared to address significant differences in information requirements and style for closure plans. The alternative cover meets the performance requirements for all of the regulatory programs but not some of the specific design details specified by NDEP. The closure plans assume NDEP will accept the cover slope and grading plan in lieu of the minimum 3 percent slope requirement. It is anticipated that practical compromises will also be reached on the passive hazard communication features, including the type, placement, and wording of warning signs and monuments.

Inclusion of the Area 5 RWMS within the groundwater use restriction for UGTA reduces the most serious risk of exposure: inadvertent drilling into the waste.

To meet the closure schedule and ensure smooth reviews, excellent communication between NNSA/NSO and the approving parties must be maintained through the closure process. Waste Management is proactively supporting the closure process by facilitating transmittal of essential information between agencies and ensuring contractor access.

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